NREL Distributed Energy and Electric Reliability Program (DEER)

Richard DeBlasio, Technology Manager

NREL DEER Program activities are carried out in support of the Department of Energy (DOE) Office of Electricity Delivery and Energy Reliability (OEDER) and the Office of Energy Efficiency and Renewable Energy (EERE).

OEDER Activities include:

- Distributed Power Systems Integration
- High Temperature Superconductivity
- Energy Storage
- Thermally Activated Technologies
- DE Power Electronics
- TAT Optimization/Controls
- DEER Communications and Website
- DEER ASERTTI Project

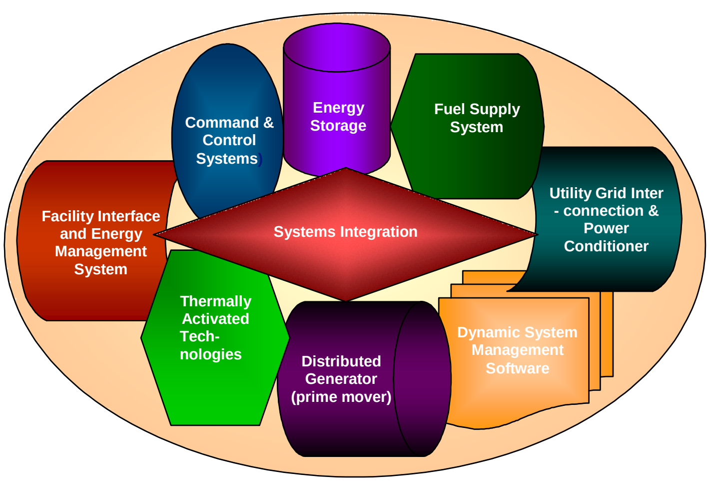
EERE Activities include:

- Nevada Southwest Energy Project

Other Activities: Collaborative Systems Integration and Advanced Power Electronics Interface R&D with the California Energy Commission

NREL Role: NREL provides technical expertise and research by conducting R&D for the two DOE Offices, The program elements are carried out through NREL internal R&D, through research partnerships, through subcontracted research, and through innovative collaborations with organizations around the country that supports the DOE Mission.

The Distributed Energy Resource (DER) Systems Integration Challenge



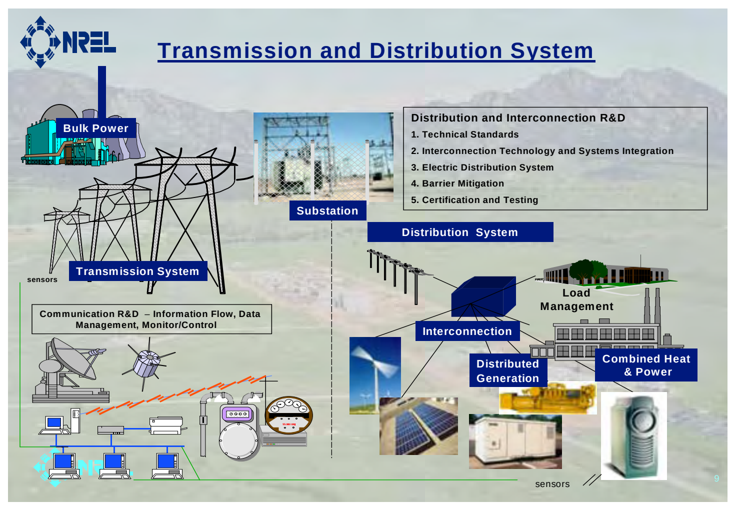
In order to transform the electrical distribution system and the ability of distributed energy resources (DER) to interface effectively with it, NREL carries out a systems integration program as shown above.

The following information briefly describes the major elements of NREL activities.

Distributed Power Systems Integration

Dick DeBlasio

Activities include RD&D of electric distribution systems; DER interconnections and system interoperability and integration technologies; and on activities that remove technical, institutional and regulatory barriers impeding the full potential of DER. This is accomplished through a collaboration of national laboratories and industry partners, strategic research, systems integration, and the mitigation of institutional barriers. Major emphasis at NREL for the DOE OEDER EDTP is addressing Distribution and Interconnection R&D as shown below.



Transmission and Distribution R&D

Integration Engineering and Testing

Ben Kroposki

Research on advanced interconnection systems, including hardware and software for DR interconnected with electric power systems.

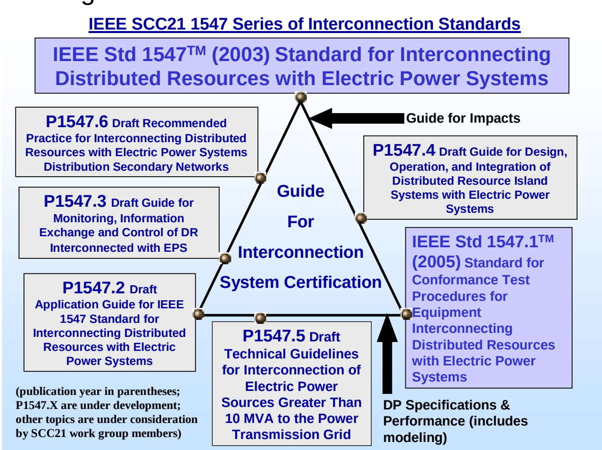
- Technical/electrical/mechanical/safety standards
- Data/communication standards
- Test procedure development and standardization
- Interconnection impacts
- Advanced concepts for distribution and interoperability
- Intentional islanding/microgrid and protection technologies
- Advanced protection schemes

- Advanced modular interconnection technology
- Adaptive control technology for aggregation, grid support
- Enterprise information management systems
- Interconnect system and equipment costing methodology
- Validation testing of prototypes
- R&D subcontracts on distribution, Interconnection standards, technologies and systems

Interconnection Engineering and Standards
Tom Basso

Development of standards and codes that address safety, reliability, power quality and interconnection issues related to the integration of distributed resources with power systems.

- IEEE P1547 series of standards for interconnection
- Technical basis for performance and testing of distribution system and components
- Interconnection systems and test methods – system, subsystem, component interfaces
- System interconnection and aggregation testing to determine system operability and compatibility with the utility
- R&D subcontracts on system characterization & testing



IEEE 1547 series of standards

Stakeholder and Institutional Adoption
Tom Basso

Working with industry, state and local government organizations to eliminate barriers to the use of distributed power.

- State and federal adoption of uniform interconnection standards/IEEE 1547
- Support for state regulatory reform to remove DER/CHP interconnection barriers
- Collaborate with ISO's and RTO's to develop regional interconnection approaches
- Support for system and equipment certification program development for DER deployment

Interface Applications and Analysis
Holly Thomas

Research on applications for distributed energy resources and analysis of benefits.

- Innovative partnerships with industry, states, and universities
- Field testing of concepts such as aggregation
- Field development of network and microgrid management and information tools
- Demonstration of systems in various field configurations and organizations.
- Field testing, test protocols, and performance data

The Distributed Energy Resources Test Facility (DERTF) is an integral part of NREL's Electric and Hydrogen Technologies and Systems Center and is designed to assist the U.S. distributed power industry in developing and testing DER systems, support standards development, and investigate other emerging, complex system integration issues.

The Distributed Energy Resources Test Facility

Co-located with the Hybrid Power Test Bed at the National Wind Technology Center, the 2,000-square-foot test facility is operational and works closely with the DP community — especially those in industry — to study and evaluate advanced or emerging DP technologies. This work includes:

Test Facility Capabilities

Engineers can evaluate the real time dynamics of DP systems, gather data on long-term performance, or demonstrate new design concepts at the DERTF. High-speed data acquisition systems monitor power quality, harmonic distortion, and electrical transients. The 200-kW grid simulator can emulate a utility, allow for voltage and frequency control, and reproduce disturbances such as sags, swells, and harmonic problems with the utility.

200-kW grid simulator

A load simulator with resistive, inductive, and capacitive elements can create power factors up to 0.37, allowing engineers to evaluate system operation under severe conditions that may be encountered in real power systems. With this equipment, researchers can investigate the power system's response to sudden load changes and to conditions of phase imbalance or loss of phase.

Researcher measures inside a 100kW inverter

Thermally Activated Technologies

Steve Slayzak

DOE works with industry to develop desiccant cooling systems for broad space-conditioning markets to realize the potential of desiccant systems for reducing energy consumption and improving indoor air quality and comfort.

NREL researchers work with industry to evaluate and test advanced desiccant cooling and dehumidification components and systems, and to develop prototypes. The goal is to develop novel materials and processing techniques for advanced systems of humidity control and mitigation of indoor air quality and airborne contaminants.

The Advanced Heating, Ventilating, and Air-Conditioning (HVAC) Test Facility, located in the Thermal Test Facility (TTF), is used to measure performance of desiccant dehumidifiers; air-conditioning components, such as heat exchangers, heat pipes, and evaporators; and entire systems. The Advanced HVAC Test Facility houses state-of-the-art humidity and pressure sensors that provide the highest available accuracy for psychometric measurements. Broader ranges of temperature and humidity test conditions as well as increased capacity are provided for testing larger devices such as enthalpy exchange and liquid desiccant systems.

The Advanced Heating, Ventilating, and Air-Conditioning Test Facility

Thermal Storage

Jerry Nix

Thermal storage activities address R&D and demonstration of advanced thermal storage systems technology integrated with renewable thermal energy technology – combined heat and power.

NREL conducts R&D and field verification of chemical energy storage systems to capture waste heat or heat from renewable energy systems. It determines the status of thermal energy storage technologies (for renewable and DG technologies). And it conducts competitive solicitations to address current thermal storage needs of DOE RE programs (i.e. materials, waste heat, etc.)

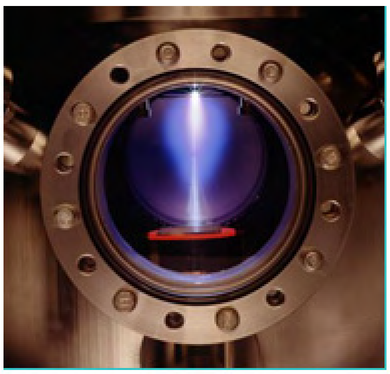
Facilities. The Field Test Laboratory Building contains 41 laboratories where a wide range of research activities are conducted to help industry use renewable resources and waste productively. Several of the laboratories focus on desiccant cooling and dehumidification technologies, including the Sorption Tests Facility, Heat and Mass Transfer Test Facility, the Desiccant Contamination Test Facility, and the Mixed Working Fluid Test Laboratory. Research conducted in the Thermal Test Facility (TTF) includes study of advanced cooling, ventilation, ventilation pre-heat, and active solar systems. In addition to housing research facilities, the building itself was designed as a research model that provides data for future building designs.

Superconductivity Research
Raghu Bhattacharya

Superconducting systems of the future will allow us to transmit electricity through power lines much more efficiently than we now can. In low-temperature superconducting materials, electric currents encounter almost no resistance. The challenge is to maintain that characteristic without having to keep the systems so cold. Already used in such applications as high-speed, magnetic-levitated trains, superconductors are being developed in laboratories such as NREL for use in microelectronics and communications.

Current R&D in high-temperature superconductivity focuses on the development of superconducting wires and other system components. Superconducting wires must be strong and flexible, and be capable of carrying a large amount of current a long distance in a magnetic field.

NREL Role. Because of their tremendous potential as a means of storing, transmitting, and distributing electricity, high-temperature superconducting materials, systems, and components are an important area of R&D in NREL's Center for Basic Sciences.



NREL's work has produced a new chemical etch that can be used in producing superconducting microelectronic circuits. We have also developed a new high-temperature superconducting film consisting of a barium-calcium-copper precursor electrodeposited on a lanthanum-aluminum-oxide substrate, followed by thallination heat treatment. Developers also achieved a world-record critical current density, which is a measure of how much current a wire can carry divided by its cross-sectional area. The goal in DOE-funded research is a critical current density of 10,000 to 100,000 amperes per square cm.

Facilities: A laboratory within the Solar Energy Research Facility (SERF) is specialized for experiments in superconductivity. For example, NREL has specially customized a pulsed laser deposition chamber to grow high-quality superconducting films.

Communications
Erik Ness

NREL publishes and communicates the results of R&D efforts, as well as key analyses needed in the DER field. A notable example is *Making Connections: Case Studies of Interconnection Barriers and their Impact on Distributed Power Projects.* National Renewable Energy Laboratory, May 2000.NREL also develops and supports the DOE DER WEB site http://www.eere.energy.gov/distributedpower/.

ASERTTI Project
Holly Thomas

NREL is participating in a unique collaboration led by ASERTTI, entitled "Collaborative National Program for the Development and Performance Testing of Distributed Power Technologies with Emphasis on Combined Heat and Power Applications". NREL worked with ASERTTI, CEC, NYSERDA and others to develop the project (co-funded by team members and DOE), and will play an ongoing role in guiding the project, developing and validating test protocols, and designing quality control systems for test data.

NREL's Nevada Southwest Energy Project
Mary Jane Hale

The State of Nevada and the U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) are working together with universities, private industry, public utilities and energy organizations to promote renewable energy research and development in Nevada and throughout the American Southwest. Nevada is uniquely positioned to take advantage of abundant solar, wind and geothermal potential. These resources, combined with its strategic position in the Western electric grid and its aggressive renewable portfolio standard, have positioned Nevada as a renewable energy center.

The Nevada Southwest Energy Partnership's (NSWEP) activities have traditionally focused on a range of technical projects. However, recent efforts have expanded to the development of renewable energy centers. DOE and NREL are providing expertise and support to help Nevada meet and potentially exceed its renewable portfolio standard ergy center of

The NSWEP Renewable Energy Centers

NSWEP's renewable energy centers will provide an umbrella to coordinate and centralize the partnership's technical projects and promote renewable energy technologies.

Three centers are currently planned:
• The University of Nevada–Reno Renewable Energy Center
• The Desert Research Institute Renewable Energy Center
• The University of Nevada–Las Vegas Renewable Energy Center

These centers will serve as regional resources and research facilities. Activities will include:

• Conducting research and development in specific renewable technology areas
• Bridging the gap between university research and development and industry to strengthen commercial market opportunities
• Training personnel in research, development, installation, operations, and maintenance of renewable energy technologies
• Providing interdisciplinary classes and teaching laboratories
• Demonstrating and validating the performance of renewable energy technologies.

Because Nevada is uniquely positioned to promote a range of renewable energy technologies, a nexus of research facilities and natural resources have come together to make NSWEP a reality.

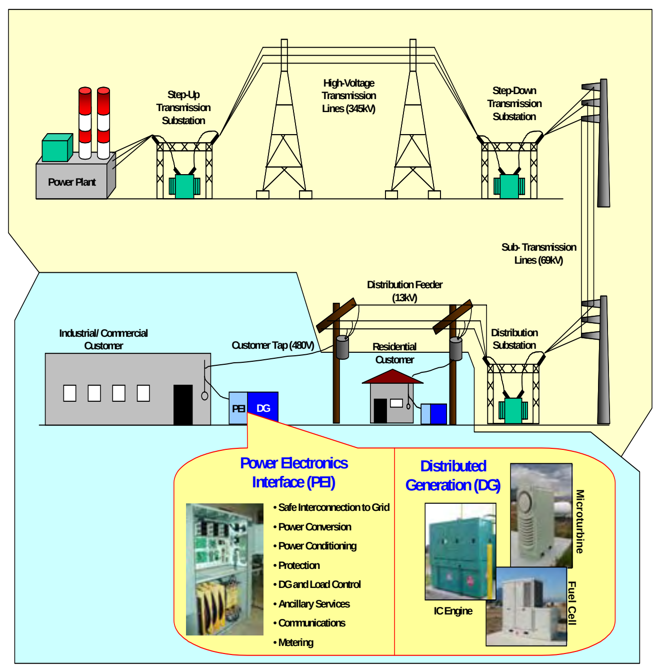
Quick Facts
• The American Southwest is an area of high potential for renewable energy resources
• Existing research facilities in Nevada include the Desert Research Institute (DRI), the University of Nevada–Reno (UNR), and the University of Nevada–Las Vegas (UNLV)

• NSWEP can help assist Nevada in meeting or exceeding its own renewable portfolio standard of at least 15% of the state's electricity from renewable sources by 2013
• Local benefits will include energy independence, less volatile energy prices, a cleaner environment, financial rewards from a renewable economy via construction and operation of in-state electricity generation facilities, component manufacturing, rural development and an increased draw to state academic and research institutions.

Advanced Power Electronics Interfaces Project
NREL- CEC- Industry Partnership

B. Kroposki, H. Thomas, T. Basso, C. Pink

The Advanced Power Electronics Interfaces (APEI) Work for Others project is a collaborative R&D effort with NREL and the California Energy Commission and industry to model and evaluate advanced power processing topologies and electronics for DE interconnection interfacing, communications and control, and operation.

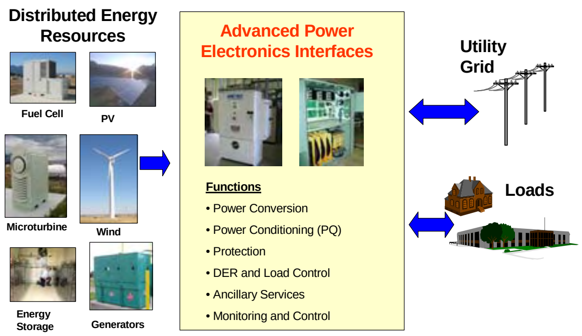


Power Electronics Systems Interface

The APEI project will identify where standardization can be used most advantageously to:
1. streamline the development of components and systems so that all elements work together;
2. create scaleable DER modules that can use interface with other modules from high-volume power electronics markets;
3. increase DER functionality including energy source optimization, load management, grid support, next generation grids, and planned islanding;

4.meet inter-connection system requirements; and 5. foster improved DER interoperability, aggregation, and penetration.

DER Power Electronics Interface



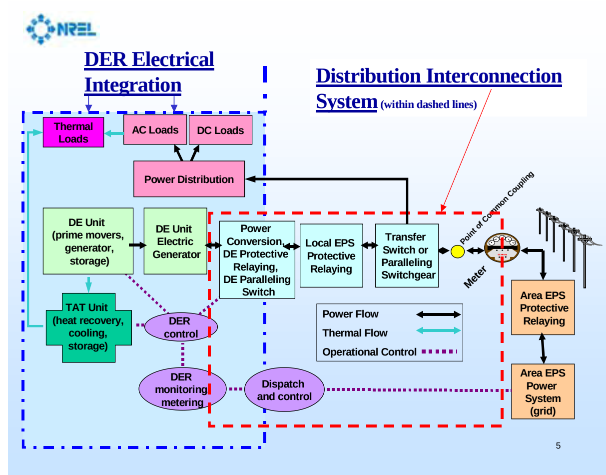
Results of the APEI R&D effort will provide complete development of advanced power electronics interface with reduced cost, improved reliability, and increased functionality. This will lead to broader application and increased opportunities for DER.

DE Advanced Power Electronics Project

B. Kroposki, C. Pink, T. Basso

The objectives of this project are to identify system integration and optimization issues and technologies and provide solutions through applied engineering research, analysis, and testing with power electronic (PE) interfaces for DE applications. In addition, this project will develop a technical basis for performance and testing of PE interfaces for DE systems, subsystems, and components. System, subsystem, and component interface performance characterization testing will be used to establish standardized measurements and test procedures. These objectives are designed to establish the potential benefits of distributed energy to provide ancillary services, enhance power system reliability, and allow customer choice.

NREL will work with its industry partners to develop electric models of power electronics interfaces. These models will help understand both how power electronic interfaces function, and characterize the impact of the distributed energy systems on the electric power system. NREL will also conduct testing to evaluate power electronic interfaces for distributed energy applications. The testing will examine the ability of the distributed energy systems to provide ancillary services such as voltage and VAR regulation, and increased grid reliability by adding additional energy sources and providing for backup power.



TAT Optimization and Controls Integration Project

Steve Slazak

The strategic research objectives of this project are to:

- Optimize thermal conversion systems that convert waste heat from onsite prime movers to heating/cooling work, to maximize their abilities to impact national source energy utilization efficiency in buildings,

-Integrate novel sensors tailored to thermal systems and quantify their abilities to improve efficiency and performance through enhanced control,

- Design, analyze and evaluate packaged, combined cooling, heating and power systems for buildings.

Based on analyses, field data, and on first-hand detailed lab data, especially full-scale equipment performance from the Advanced Thermal Conversion Laboratory, optimize sensors, air-cleaners, and thermal conversion components and integration approaches that have the greatest likelihood of reaching DE Program objectives.

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